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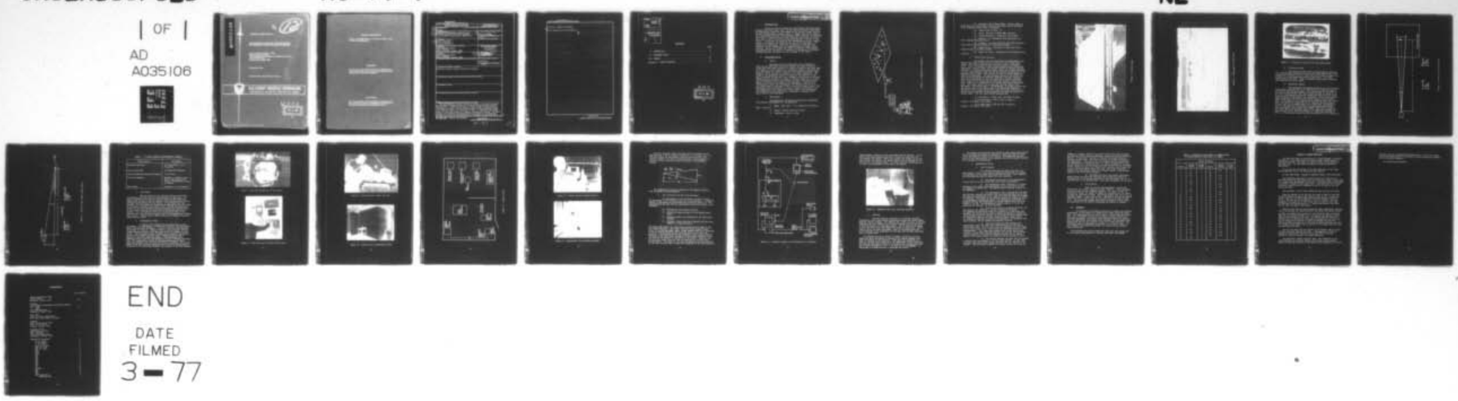

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TECHNICAL REPORT RG-7T-7

EVALUATION OF THE EFFECT OF TARGET MOTION ON TARGET DETECTION TIME USING A TV SENSOR

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28 September 1976

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The work discussed here was conducted in support of an internal research and development program conducted by the Missile Systems Division, Rockwell International, to determine the effect of target motion on target detection time using a TV sensor. Equally divided groups of fifty-one subjects viewed a TV displayed scenario of a stationary, a slow, or a moderately fast moving target of a tank type vehicle in a lightly cluttered rural setting. The report includes the laboratory configuration and the procedures of the experiment. Analysis of the data was the responsibility of Rockwell International and is →

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CONTENTS

I. INTRODUCTION

The *Electro-optical simulation system* (EOSS) Simulation Group, Advanced Simulation Center (ASC), US Army Missile Research, Development and Engineering Laboratory, was engaged by the Missile Systems Division, Rockwell International, Columbus, Ohio, to support them in the conduct of an Independent Research and Development (IR&D) experiment to determine the effect of target motion on target detection time using a TV sensor. This report covers the activities and participation of the ASC in that effort. It describes the equipment and instrumentation setup, scenario, subjects, procedures, and other factors used in the experiment. The design of the experiment, reduction, and analysis of the data and reporting of the findings were the responsibility of Rockwell International. Because the program was funded by Rockwell's IR&D program, the measured data and results of analysis are the property of Rockwell International and, therefore, are not included in this report.

II. EXPERIMENT SETUP

A. General

The objective of the experiment was to determine if there was any significant difference between the times to detect a moving tank type target located in a lightly cluttered (tree-line) area at a range of 5 km as compared to a stationary target in the same area when the subject was using a black and white television display representative of the one used by a gunner in an assault helicopter. The design of the experiment called for setting up the scenario on the 600:1 scale EOSS terrain model and, through a closed circuit television system, display the scene to a group of subjects, taken one at a time, and measuring the time for each subject to detect the target vehicle. Figure 1 illustrates the scheme of the experiment. Based upon the experimenter's inputs and requirements, the scenario was set up on the terrain model in the area of one of the moving target tracks. The background scene was modified to produce a lightly cluttered or tree-line background to the target and a clear field of view foreground. The following sections describe the requirements, equipment, and other facets of the experiment.

B. Requirements

The experimenter (Rockwell International) established the following requirements for the experiment:

1) Range: Real world - 5 km (laboratory distance at 600:1 = 328 in.).

2) Target: Typical tank type vehicle.

3) Atmosphere: Clear; no haze.

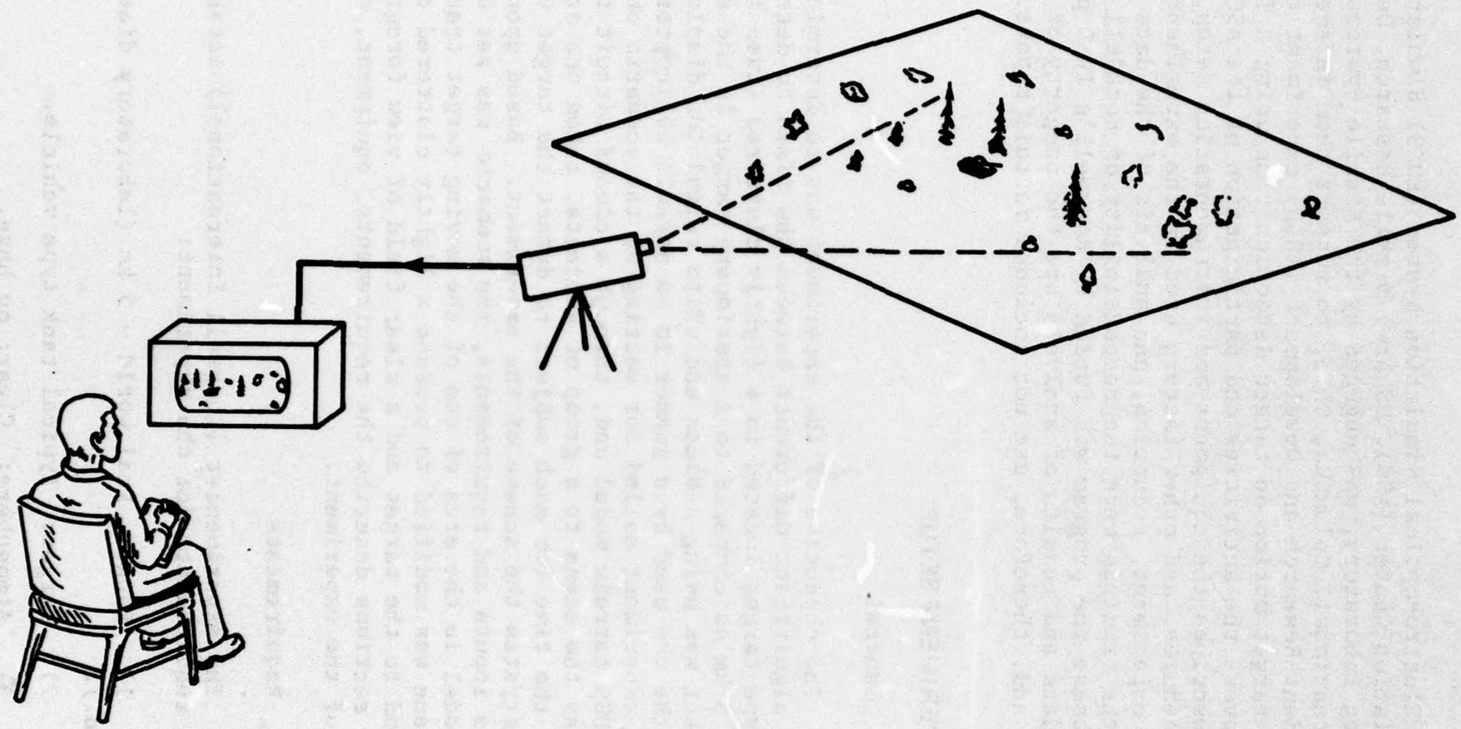


Figure 1. Schematic of experiment.

4) Altitude: Nap of Earth (NOE): minimum height at which there is a clear field of view of the target and its surrounds; to be determined during setup of equipment.

5) Sensor Field of View: 3°.

6) Scale: Suitable to EOSS; 600:1 selected.

7) System Resolution: 0.085 mrad (450 TVL/RH).

8) Display: 4:3 rectangular array equivalent to a 5-in. diagonal viewed at 18 in.

9) Subjects: Fifty-one subjects with 20/20 corrected vision and no previous exposure to laboratory equipment.

10) Target motion: Stationary, 3 m/sec and 6 m/sec perpendicular to the line-of-sight.

11) Number of trials: Seventeen for each target motion condition.

C. Terrain Model Scenario

The scenario for this experiment was established on the EOSS terrain model in the vicinity of one of its two moving target tracks. This three-dimensional terrain model (Figure 2) measures 32 ft × 32 ft, is basically a 600:1 scaled composite world possessing land masses, natural growth, and cultural features of general military interest. It contains two moving target tracks, one of which possesses two 5 ft long orthogonal legs with one leg running perpendicular to the downrange line-of-sight. This section of track is the one which was used in the experiment. The terrain model surface in the vicinity of this track was modified by removing foreground trees and covering up trees in the background so that the result was a lightly cluttered rural scene with the target vehicle portrayed against a sparse tree-line. Figure 3 is a photograph of the target area used in the experiment. The target vehicle can be seen near the right side of the photograph. The aspect angle of the photograph is somewhat greater than the line-of-sight of the camera used in the experiment (Figure 4). The motion of the target was preset so that any of the three states of motion could be selected through switches on the EOSS Test Director's control panel. The real world motions selected were:

1) 0 stationary in right, left, or center of scene.

2) 0 moving right to left or left to right at 3 m/sec = 10.8 km/hr = 6.75 mi/hr.

3) 0 moving right to left or left to right at 6 m/sec = 21.6 km/hr = 13.5 mi/hr.

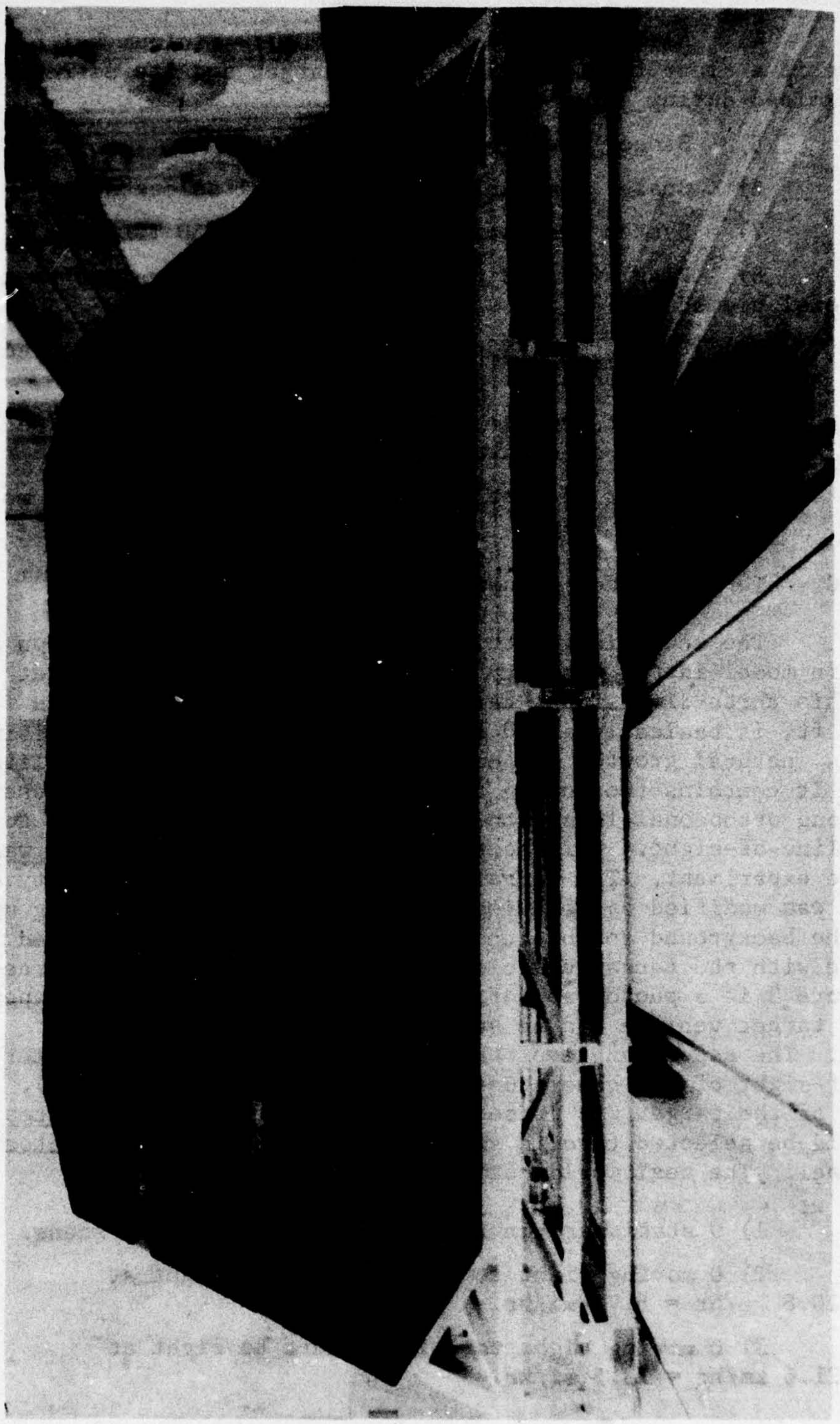


Figure 2. Terrain model.

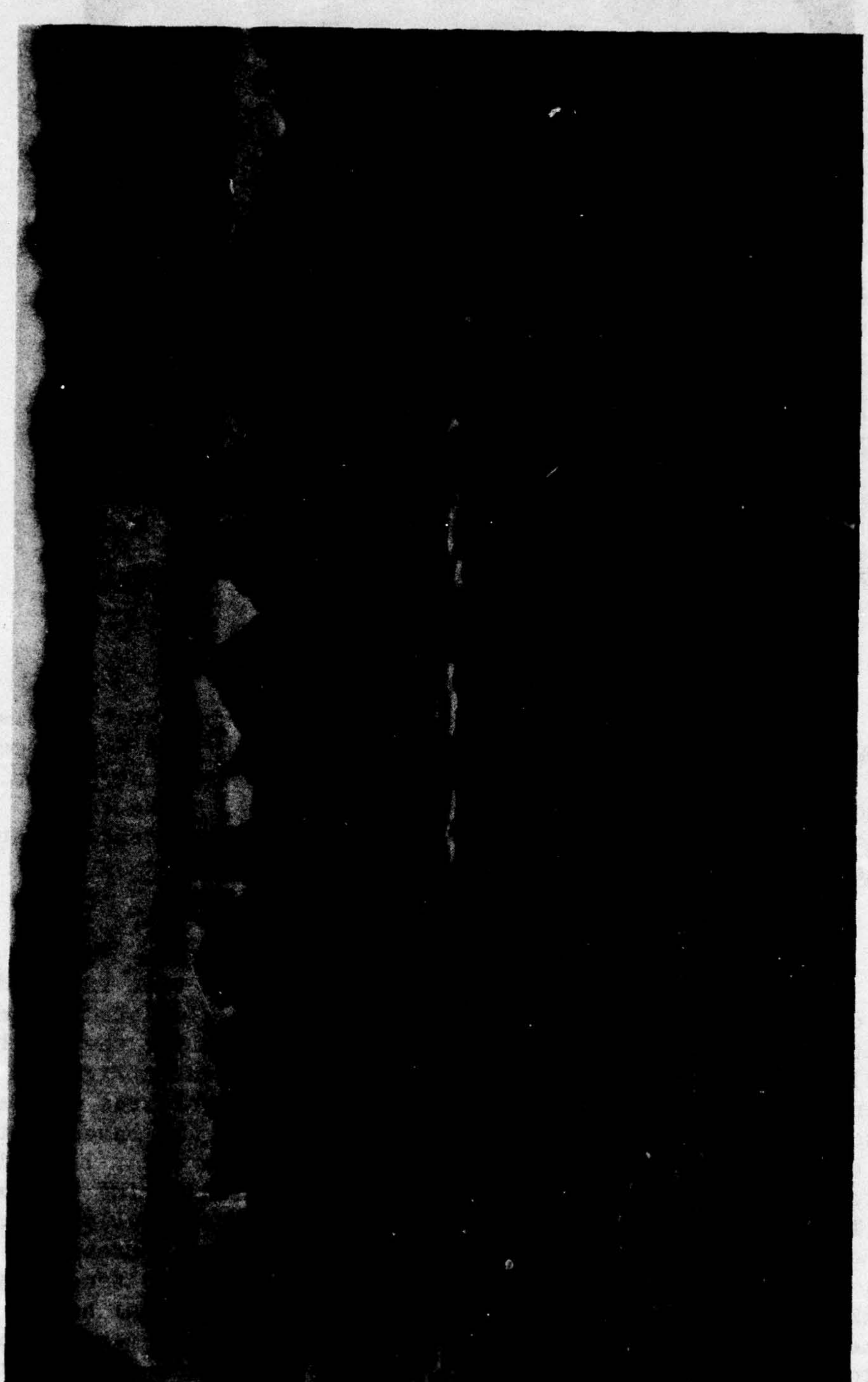


Figure 3. Photograph of target area.

Figure 4. TV display of scenario with time superimposed.

D. Television System

The television system used in the experiment consisted of a COHU 6210 high resolution TV camera and a COHU 6900 Series camera control unit which was set for a scan rate of 875 lines per frame, and a CONRAC 14 in. high resolution monitor (Model KQA). The camera vidicon was an RCA 4503A. Table 1 summarizes the important operating characteristics of the TV system.

E. Experiment Geometry

The experiment requirements specified that the TV display should cover a field of view of 3° horizontal at a simulated range of 5 km with an NOE depression angle. The calculations for the width of the field of view on the 1:600 terrain model as shown in Figure 5 was 17.16 in. The depression angle for viewing the target area was determined during the setup phase of the experiment. It was based upon the lowest elevation of the camera which would present a clear line-of-sight to the target for any target position required during the experiment. The target was positioned 328 in. from the vertical plane of the face plate of the camera which, on a 1:600 scale, corresponds to 5.0 km. The camera was then elevated and depressed simultaneously until the desired line-of-sight was reached. The vertical height of the camera above the horizontal plane of the target was measured and found to be 17.66 in. which corresponds to a real world altitude of 261.1 m. The depression angle was then calculated to be 3.0° (Figure 6).

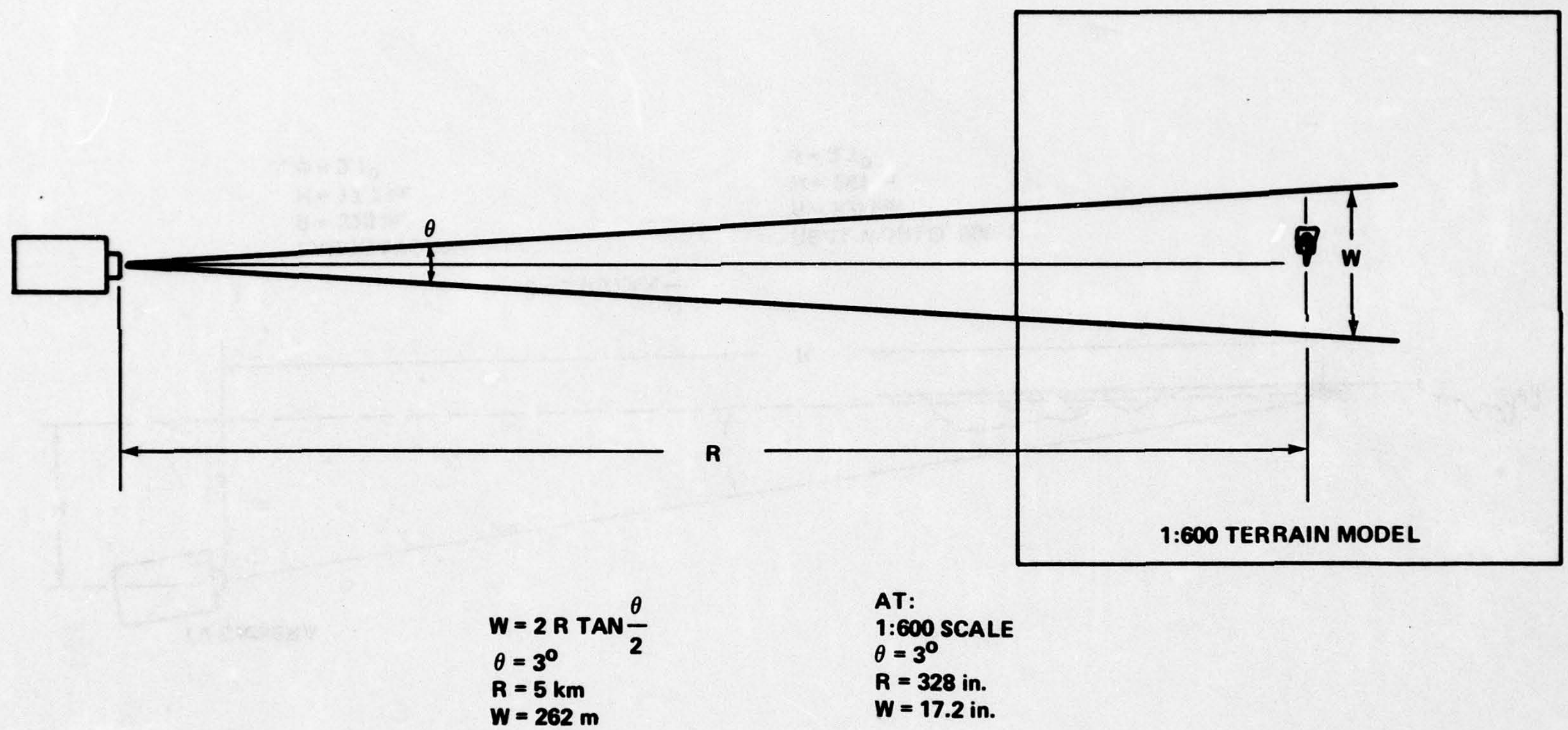


Figure 5. Field of view calculation.

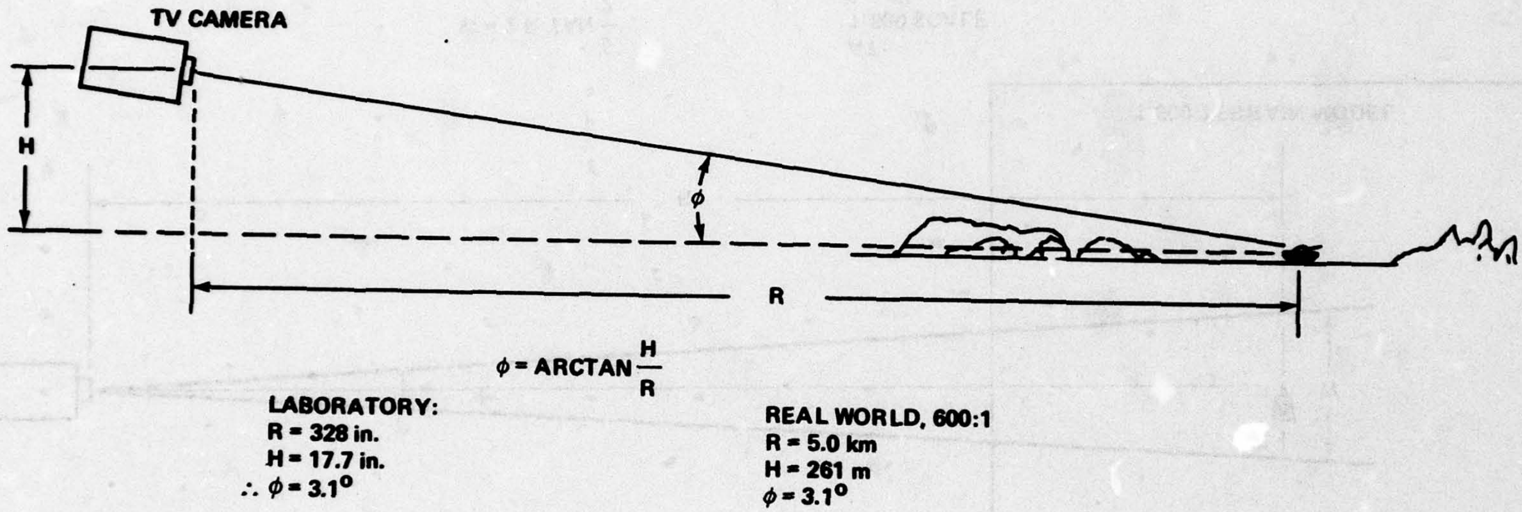


Figure 6. Elevation and target aspect angle.

TABLE 1. TV SYSTEM OPERATING CHARACTERISTIC SUMMARY

Characteristic	Performance
Horizontal Scan Rate	875 lines/frame, 2 to 1 interlaced
Vertical Scan Rate	30 frames/60 fields/sec
Limited Horizontal Resolution (Center)	775 TV lines
Gray Scale Response	Resolves 10 shades of gray EIA TV chart using 15 ft candles illumination on face of vidicon
Video Output	Composite, 1.0 V processed

F. Lens System

The lens used with the television camera to provide a 3° horizontal field of view was a Rank-Varotal 16:1 zoom lens. The lens was mounted on the front of the roll gimbal of the three-axis flight table (Figure 7) and was coupled to the television camera which had been mounted inside the roll gimbal. As the flight table was elevated, the pitch gimbal was depressed and adjusted so that the center of the target area was on the optical axis. The lens was zoomed and focused so that the horizontal display encompassed the required width of the terrain model and the center 50% of the display was sharply focused. Due to the narrow field (3°), the depth of field of the scene was such that the near foreground and far background were slightly out of focus. (Figure 8 shows camera control unit; Figure 9 shows the camera and zoom lens.)

G. Experimenter's Booth

A special booth (Figure 10) was constructed to house the subject, the experimenter, the EOSS Test Director, recording instruments, and monitoring equipment. A layout of the booth and equipment is depicted in Figure 11. Figure 12 shows a typical subject with the target detection switch in his right hand and his TV display in front of him. The experimenter shown in Figure 13 was seated by the subject where he could operate the strip chart recorder which was used to measure the subject's detection time(s). The experimenter also possessed control boxes for initiating the runs and resetting the equipment. The background of Figure 12 discloses monitoring and video recording equipment which the EOSS Test Director operated. The curtain shown at the left was closed during trials so that the subject was not distracted by the monitoring equipment and presence of the test director.

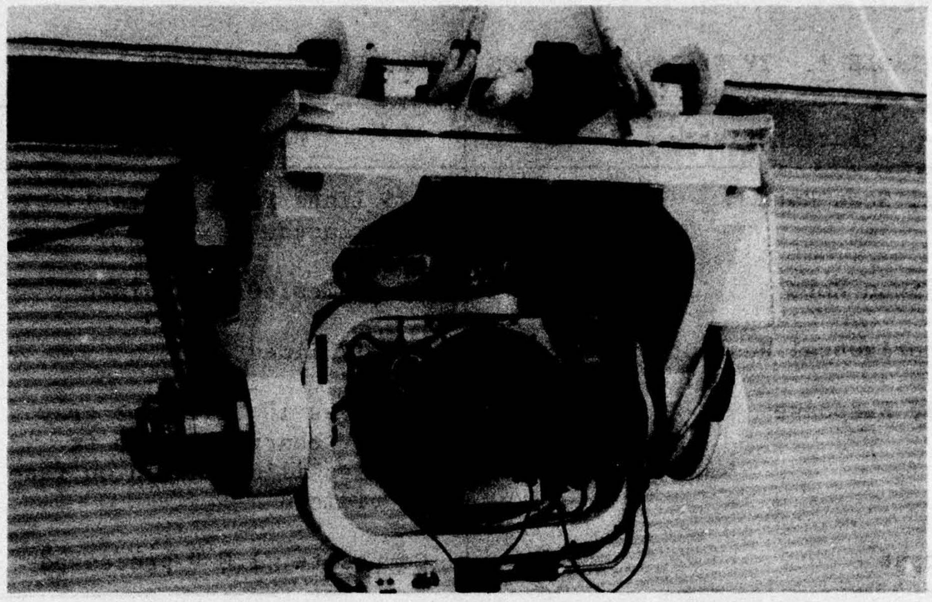


Figure 7. Zoom lens mounted on a 3-axis table.

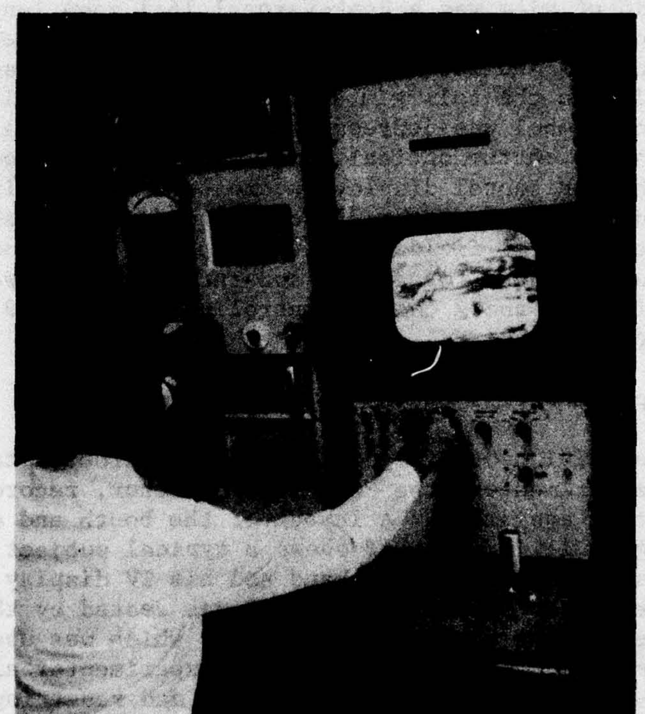


Figure 8. High resolution TV camera control unit.

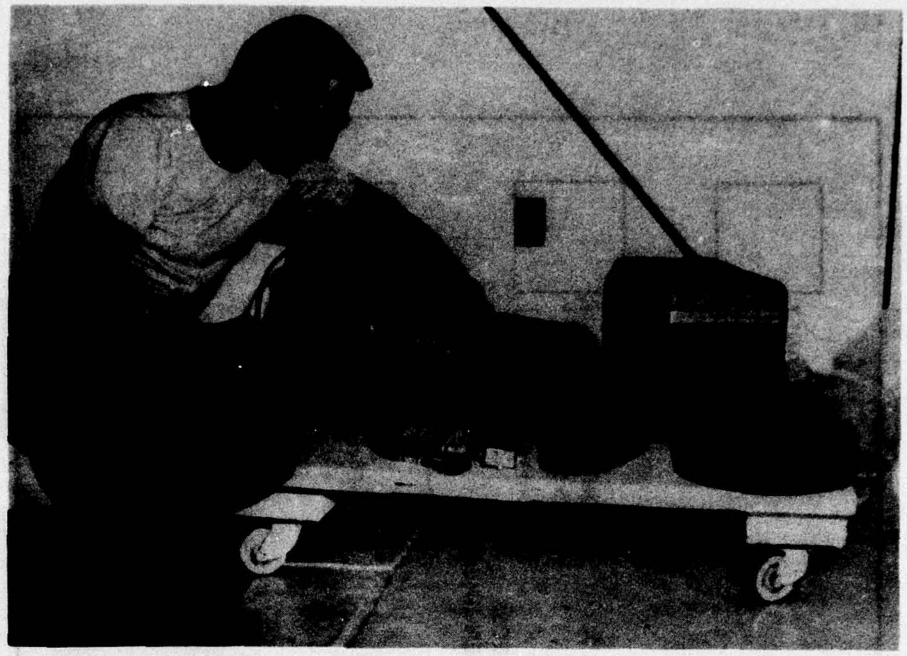


Figure 9. High resolution camera and lens.

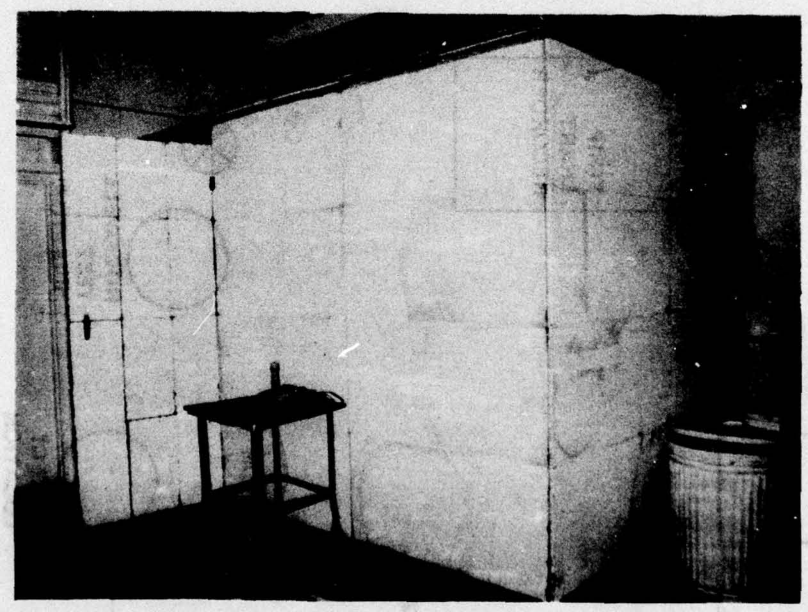


Figure 10. Outside view of experiment station.

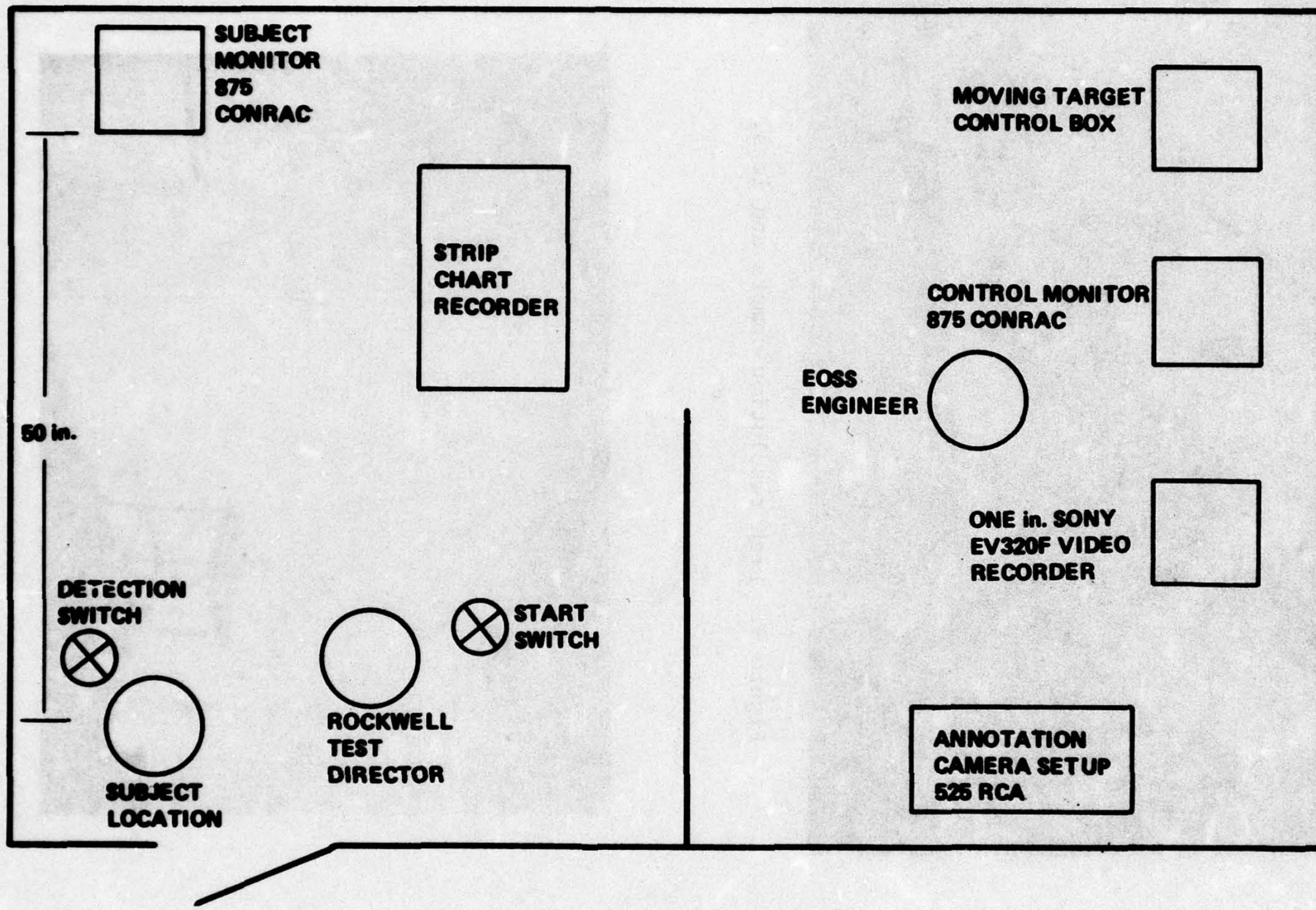


Figure 11. Subject booth.

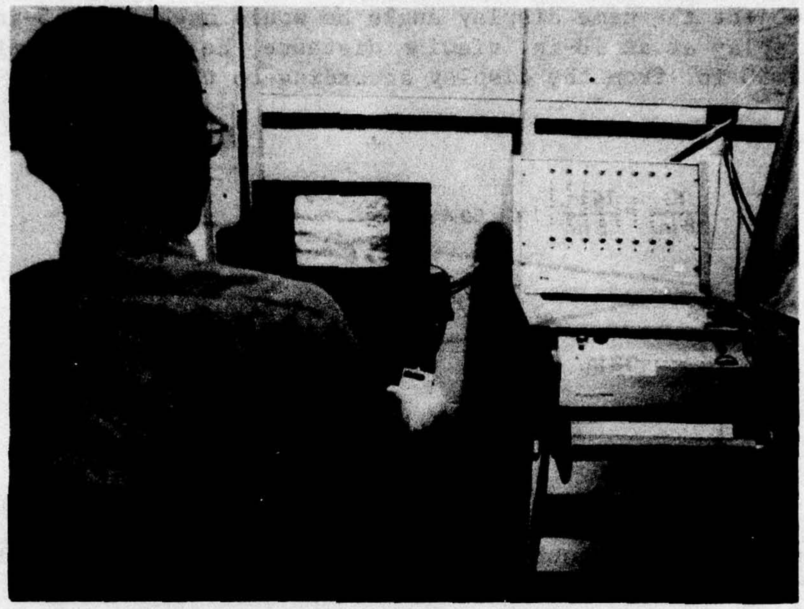


Figure 12. Subject and his scenario display.

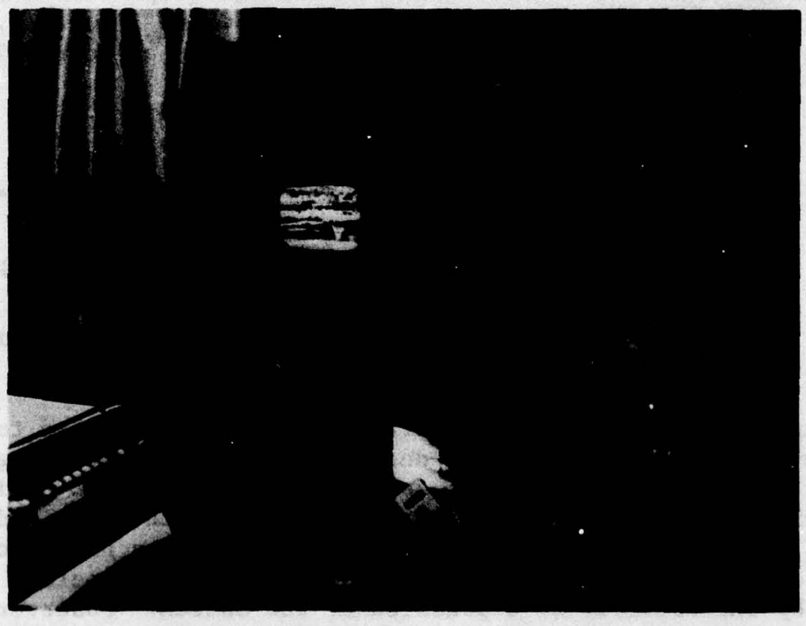
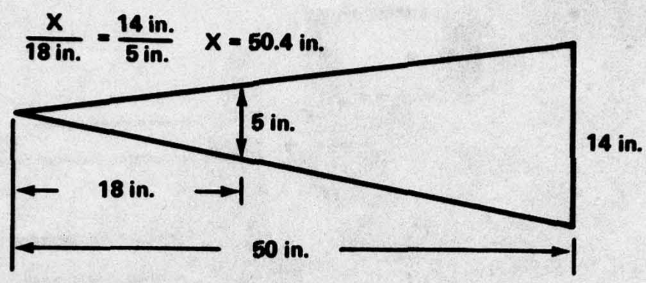


Figure 13. Experimenter and recording equipment.

The only compatible high resolution monitor available for the experiment had a 14-in. diagonal rectangular (4:3) display area. To give the subject the same display angle he would have for a 5-in. diagonal display at an 18-in. viewing distance, he was seated at a distance of 50 in. from the display according to the following diagram:



The brightness and contrast settings on the subject's monitor were optimized by the experimenter.

H. Data Collection and Monitoring Equipment

The experimental trial procedures provided the basis for the design of data collection and monitoring equipment. A schematic diagram of the layout and interconnection is shown in Figure 14. The implementation was such that the experimenter would have control of the following:

1) Illuminating the subject's monitor.
2) Initiating target movement for the moving target cases.
3) Causing a pulse to be indicated on the strip chart recorder.
4) Starting a timer which would indicate the time from "unmask" to target detection.

The subject had control of a push button switch which he used to indicate target detection. The target detection switch stopped target motion for the moving target cases, caused another pulse to be indicated on the strip chart recorder, and froze the value of the time code generator. The detection switch was designed so that a pulse would be indicated on the strip chart recorder for each target detection indication made by the observer by depression of the switch. Observer time for the first target detection time was generated by the EOSS time code generator. The output of the time code generator was superimposed on the video from the COHU TV camera and displayed on the test director's

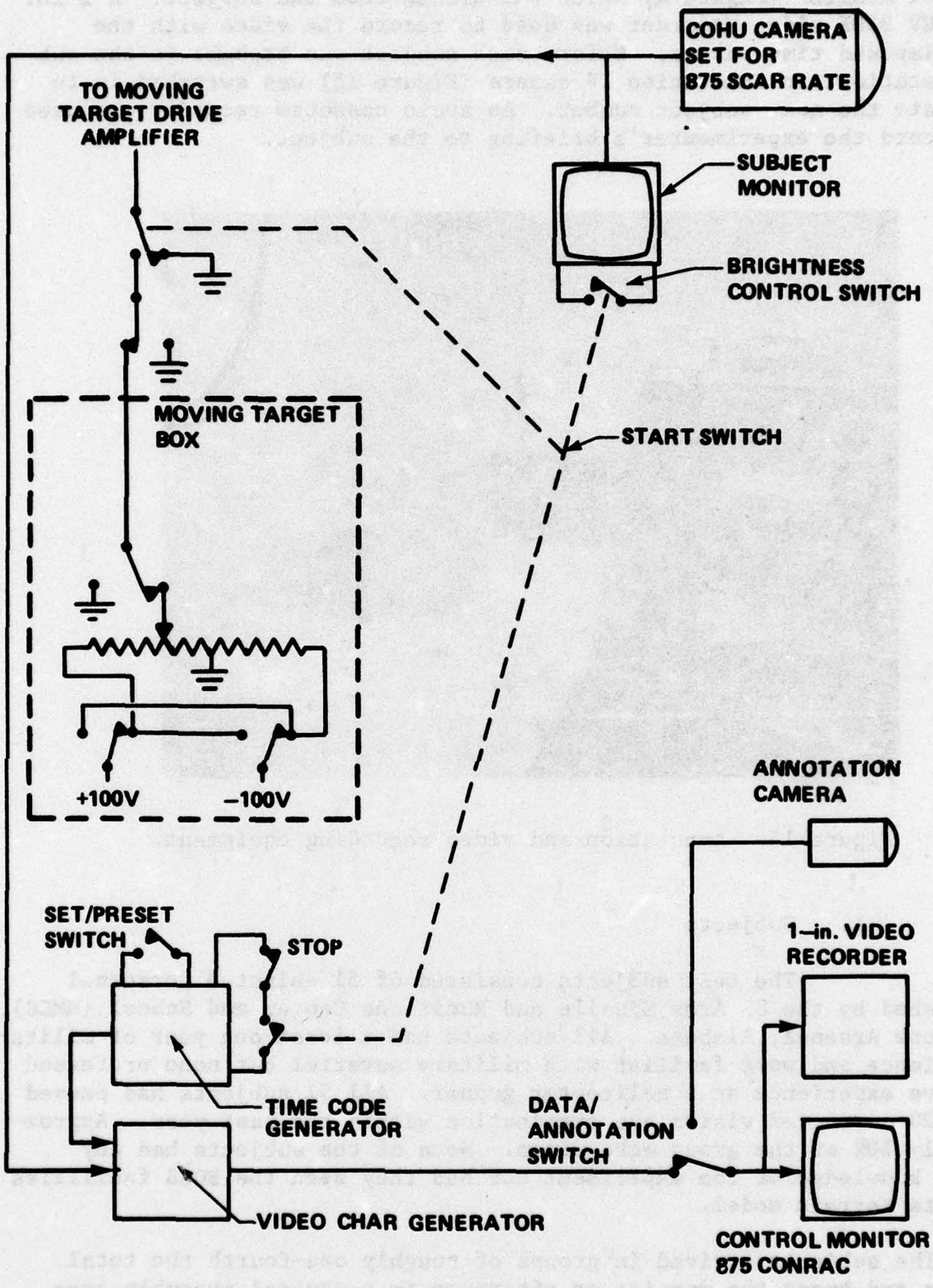


Figure 14. Schematic diagram of interconnection of equipment.

control monitor (Figure 4) which was hidden from the subject. A 1-in. SONY EV 320F video recorder was used to record the video with the superimposed time values. Before each subject was brought in the subject station, an annotation TV camera (Figure 15) was switched in to indicate the next subject number. An audio cassette recorder was used to record the experimenter's briefing to the subject.

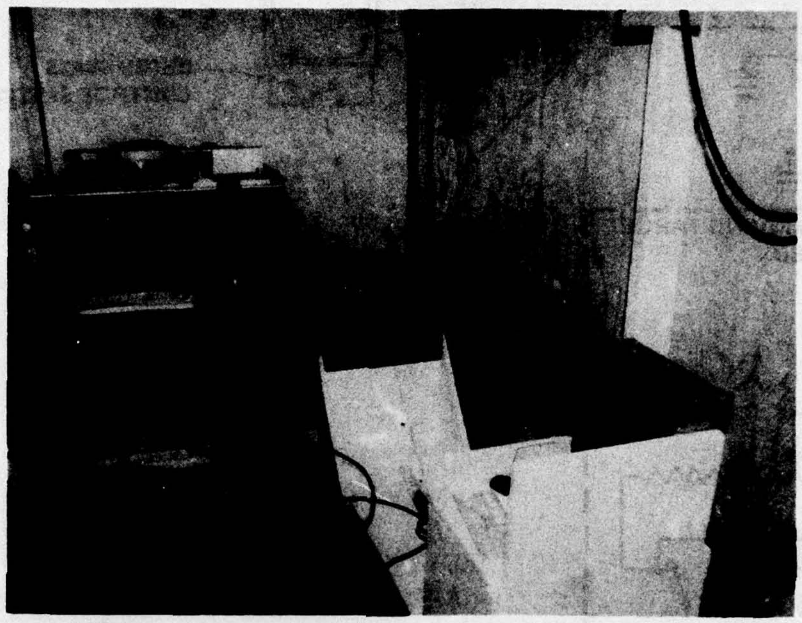


Figure 15. Annotation and video recording equipment.

I. Subjects

The test subjects consisted of 51 enlisted personnel furnished by the US Army Missile and Munitions Center and School (MMCS), Redstone Arsenal, Alabama. All subjects had a least one year of military experience and were familiar with military materiel but none professed to have experience as a helicopter gunner. All 51 subjects had passed a 20/20 corrected vision eye examination within the past year. Approximately 10% of the group were women. None of the subjects had any prior knowledge of the experiment nor had they seen the EOSS facilities and its terrain model.

The subjects arrived in groups of roughly one-fourth the total number and spent the morning or afternoon in a general assembly area under the monitor of ASC personnel. Each group was prebriefed as a whole by the EOSS Group Leader as to the importance of their participation and upon the need for them not to discuss their observations with any of their colleagues so as to avoid bias due to preknowledge. A subterfuge of scoring was used to encourage the latter.

The subjects in each group were allowed to draw random mixed numbers from a box which delineated the sequence in which they would be taken to the experimenter's station by an escort. Following each subject's trial, he was escorted back to the assembly area and once again cautioned not to discuss his observations.

J. Experimental Trials

1. Trial Procedure

The following sequence of events took place for each subject's trial. This plan was developed and checked out against a group made up of personnel associated with the EOSS. Their comments and criticisms were used to adjust the trial procedure.

a) The subject is escorted to the experimenter's station where he is met outside the booth by the experimenter.

b) The experimenter reads a portion of a written briefing to the subject using photographs of the scene which he will be viewing as a visual aid. (The entire subject briefing is given in the Appendix.)

c) The experimenter, after checking with the EOSS Test Director, escorts the subject into the booth and seats him so that his eyes are approximately 50 in. from the TV monitor which will display the scenario. The screen on the subject's monitor is blanked out prior to the subject's entering the booth. The experimenter continues the prepared briefing and demonstrates the target detect switch which the subject is to use. The experimenter asks the subject if he has any questions and clarifies any such questions.

d) Prior to the subject's entering the booth, the test director has performed a number of functions including: (1) changing the annotation board and recording it on the video tape recorder, (2) setting up the target position and motion as called for in the "Target Situation" matrix, (3) switching the video recorder from the annotation camera to the high resolution camera output video, (4) calling for zeroing of the time code generator, (5) turning on the audio recorder, and (6) blanking the subject's display.

e) After the subject has been briefed, the experimenter starts the strip chart recorder which will be used to record event times. He then calls ready and depresses the trial start button on his control box. This causes the following actions to occur simultaneously: (1) a time pulse places a mark on the strip chart recorder, (2) the EOSS time code generator is started, (3) the target scenario appears on the subject's display monitor, and (4) starts motion of the target vehicle (if called for in the particular trial).

f) The subject searches the scene until he locates a feature which he considers to be the target vehicle. At that time, he presses the target detect button (and may call out "detect" if he wishes). When the subject presses his "detect" switch, he causes his

display to "freeze," places a time pulse on the strip chart recorder, and freezes the EOSS time code generator reading on the Test Director's monitor. He then uses a pointer to indicate the feature which he detected as the target. His answer is noted to be right or wrong by the experimenter. The subject has the freedom without coaching from the experimenter to change his mind. If, after he pushes the "target detect" switch he is of the opinion that what he saw was not the target, he may continue to search and "detect" until either he has stopped the trial or the experimenter stops the trial. Each time during such a sequence that the subject presses the "detect" switch, a timing pulse appears on the strip chart recorder.

g) Following the trial, the subject and experimenter discuss any questions which may have arisen; the subject is cautioned not to divulge his experience to his colleagues; then he is escorted back to the assembly area. This ends the sequence of one trial.

2. Trials Matrix

Prior to start of the experiment, a matrix was drawn up for the various target situations (Table 2). Three different situations were run for stationary targets: (1) target in left (L) one-third of scene, (2) target in center (C) one-third, and (3) target in right (R) one-third of scene. The moving targets were set up for two different speeds: 3 m/sec and 6 m/sec. One-half of the moving targets moved from left to right (L-R) and the other half from right to left (R-L). The situations changed from subject to subject to help reduce any opportunity of one subject influencing the efforts of another.

III. SUMMARY

The objective of the EOSS activity was to support the Rockwell experimenter in the conduct of a human factor target detection experiment. The responsibilities of the ASC were to provide laboratory hardware, set up equipment, provide test subjects, operate facility and monitoring equipment, and provide other necessary support as required. Once the experimental requirements were available, all equipments were acquired and set up, and a series of "dry run" trials were made. The preliminary work was completed on schedule. As a result, data on 51 test subjects were taken and recorded in a two-day period without a single malfunction.

The resulting time record charts and other data were turned over to the Rockwell experimenter for analysis and report of findings.

TABLE 2. EVALUATION OF THE EFFECT OF TARGET MOTION ON TARGET DETECTION TIME USING A TV SENSOR

Target Situations					
Subject	Target Location	Target Speed	Subject	Target Location	Target Speed
1	L	0	27	R-L	6
2	L-R	3	28	L	0
3	R-L	6	29	R-L	3
4	C	0	30	L-R	6
5	R-L	3	31	C	0
6	L-R	6	32	L-R	3
7	R	0	33	R-L	6
8	L-R	3	34	R	0
9	R-L	6	35	R-L	3
10	L	0	36	L-R	6
11	R-L	3	37	L	0
12	L-R	6	38	L-R	3
13	C	0	39	R-L	6
14	L-R	3	40	C	0
15	R-L	6	41	R-L	3
16	R	0	42	L-R	6
17	R-L	3	43	R	0
18	L-R	6	44	L-R	3
19	L	0	45	R-L	6
20	L-R	3	46	L	0
21	R-L	6	47	R-L	3
22	C	0	48	L-R	6
23	R-L	3	49	C	0
24	L-R	6	50	L-R	3
25	R	0	51	R-L	6
26	L-R	3			

Appendix A. SUBJECT BRIEFING

You have been asked to participate in a study designed to evaluate the ability of the human operator to detect tanks visually using a television display. The target for which you will be searching will look like this. (At this time the subject is shown the briefing photographs.)

As you can see, the target is not very large and, at the range being simulated (5 km), you cannot see many details.

GO INTO TEST BOOTH. BALANCE OF BRIEFING GIVEN AT LOW LIGHT LEVEL.

The simulation represents a situation where you would be in a helicopter which has just cleared the trees and has a clear line-of-sight to a target area approximately 5 km away. A tank which may be stationary or moving is located in that target area. Your task will be to search the scene visually which is displayed on the TV in front of you and locate the tank.

The procedure we will follow during the test will go as follows:

When you indicate to me that you are ready to begin, I will turn on the TV display you see on the table in front of you. The instant the TV comes on, you should begin searching the displayed scene for a tank. The tank may be stationary or it may be moving. The only guarantee I can give you is that there will be a tank in your field of view when the display comes on. I should also mention that there will be only one tank in the picture.

When you feel that you have located the tank, immediately indicate this by depressing the target detection (T_D) switch and saying "target." In order to determine the accuracy of your detection call you should then use the pointer provided to you to point to the object on the TV which you have decided is the tank. If, during the time after your initial call, you decide that the object you selected is not the tank, say "no target" and continue to search the display for the tank. Follow the same procedure as for the initial target detection and call out "target" while pushing the T_D switch, or "no target" until you feel you have found the tank.

You will be timed from the instant the TV display comes on until you have correctly detected the tank. I encourage you to work as rapidly as possible but incorrect calls also will be recorded. Therefore, time and accuracy are equally important.

One additional comment should be made. The foreground of the scene displayed on the lower portion of the scene and the distant horizon on the upper portion of the scene will be slightly out of focus.

The tank will not be hidden within these areas. It will be located within the center third of the display vertically and may be anywhere on the horizontal dimension.

Do you have any questions?

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